

# Testing of Regional Wind Erosion Models For Environmental Auditing

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## Introduction

In 1999, a community-government partnership in natural resource management was established in New South Wales, Australia. Catchment Management Boards (CMB) have been established with members drawn from representatives of the community, industry and government. The objective of the 18 CMB is to enhance the capacity of total catchment management to substantially improve the quality and sustainability of our state's natural resources and environment. Each of the CMB has developed a draft Blueprint to ensure the health of the landscape is improved by meeting key targets. Wind erosion monitoring is an integral part of the targets in the drier regions of the state because it monitors the performance of several of the key catchment targets including soil ground cover, soil health, and identification of areas that require regeneration and rehabilitation.

Monitoring of wind erosion over south-east Australia was undertaken by two independent methods. The first method was an integrated wind erosion modelling system as outlined by Shao (2000); the second was a dust visibility index based on Bureau of Meteorology (BOM) visibility observations.

This paper presents a methodology for validating regional scale models like the Integrated Wind Erosion Modelling System (IWEMS) against observational data. An evaluation of the process is given discussing its application to environmental auditing.

## Materials and Methods

The area under study is south-east Australia. One year (1999) was selected, as it was an active wind erosion year in the study.

### Integrated wind erosion modelling system

Full details of IWEMS can be found in Shao (2000). In brief, the system contains three components 1) an atmospheric-prediction model, together with land-surface model, 2) a wind erosion model, and 3) a geographic information database. The

computation of friction velocity ( $u_*$ ) is via the Monin-Obukhov similarity theory, which depends on near surface wind speed, surface roughness and atmospheric boundary layer stability. The calculation of threshold friction velocity ( $u_{*t}$ ) requires information of soil type, vegetation and soil wetness where  $u_{*t} = u_{*t}(\text{ideal}) \times \text{modification factors}$ . The modification factors are correction functions for surface roughness, soil wetness and other factors. Soil wetness is determined using a land surface parameterisation scheme (ALSIS, Atmosphere and Land Surface Interaction Scheme). The vegetation type is based on data from the Australian Resource Data and the leaf area index is derived from satellite remote sensing data of NDVI. The IWEMS system is first run over the Australian continent with a 50 km resolution. The resolution for the NSW region is 10 km. The increased resolution is achieved through a nesting procedure for both the atmospheric model and the land surface wind erosion model.

### Dust Visibility Index

Meteorological records of dust event occurrence and intensity were obtained from the Bureau of Meteorology. Previous work has used dust event frequency (McTainsh and Pitblado, 1987) and a dust storm index (McTainsh et al., 2001, McTainsh and Tews, 1999) to measure spatial and temporal aspects of wind erosion. One of the main weaknesses of these data is the inconsistencies in meteorological observer records of the various dust event codes. The DVI overcomes this problem by using the visibility reduction at the time of the event (which is closely related to dust concentration) as the measure of wind erosion intensity, rather than the event codes. An example is given in Table 1.

**Table 1. Example of weather observation records**

Location	Station	Long	Lat	Date	Time	Pre s	Pas t	WindS (km/h)	WindD ir	Vis (m)
RABBIT FLAT	15666	130.01 48	- 20.182 5	2000090 1	0900	7	1	33.5	220	1000 0
BIRDSVILLE	38002	139.34 86	- 25.900 3	2000090 1	0900	7	7	42.5	360	4000 0
ALICE SPRINGS	15590	133.88 78	- 23.796 8	2000090 1	1200	6	1	31.3	220	4000 0

DVI was calculated using Equation 1.

$$DVI = 0.60014 - 0.13032 \log_e(\text{visibility km})$$

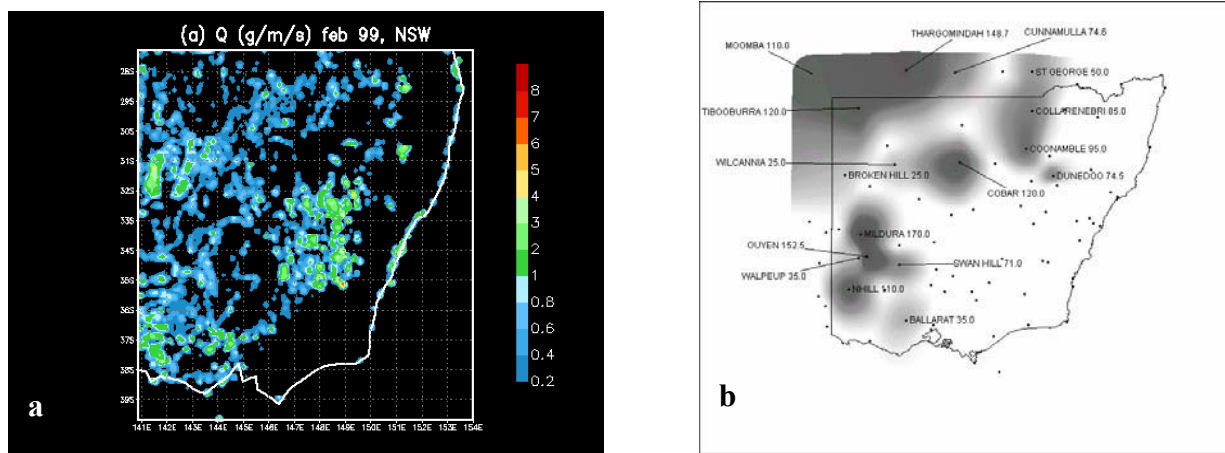
(1)

Equation 1 is derived from the power relationship between visibility and dust concentration measured at distance from source with a high volume air sampler (Tews 1996). The visibility / dust concentration equation was normalised to account for visibilities from 0.0456km (DVI of 1) to 100 km (DVI of 0) in line with Equation 1. DVI readings were summed for each month to indicate regions of dust activity.

## Results and Discussion

The output from both methods for one month is shown in Figure 1. There is basic agreement between the methods as seen in Figure 1. The spatial resolution of each method and an understanding of what each method is measuring can account for differences in the spatial location of the dust activity. Differences in what each approach measures adds to the difficulty of a direct comparison, ie IWEMS predicts saltation activity with relatively high resolution (10 km pixel) and DVI measures the dust in the air at some point, or down wind of, the erosion source area at a lower spatial resolution; represented by the dots in the Figure 1b.

The results indicate that IWEMS is working well in the western (drier – rainfall decreases away from the eastern coast) areas but does not pick up the activity in the central part of the state.



**Figure 1. Wind erosion distribution over SE Australia for February 1999 with predictions from (a) IWEMS and (b) DVI observations**

### What to measure and at what sampling interval?

The accuracy of any method will largely depend on these questions provided the scheme is sound. In the case of IWEMS, even with today's computer/information systems it is still a complex issue to handle all the data. Therefore, those parameters that do not change rapidly over time (vegetation structure, overall roughness length, soil particle-size, salt concentration and crust strength) do not have to be updated very often. Other factors like surface roughness length, fraction of erodible area and frontal area index, need to be updated more often. Finally, wind speed and soil moisture need to be updated on short time steps. Achieving all the above becomes increasingly difficult as the update period decreases. Using remote sensing for groundcover has been undertaken using monthly NDVI. NDVI relies on changes in the greenness index, which is not always linked to cover in semiarid areas and may result in a lower cover level being assigned. Despite this, Shao and Leslie (1997) have successfully used this approach. The wind erosion model used (WEAM, Shao et al. 1996) is very sensitive to soil moisture. This parameter should be estimated at the highest resolution as should wind speed.

In the case of DVI, what to measure has been limited by the availability of data in the BOM database. The biggest limitations for the database are spatial distribution of

the stations and temporal resolution of recordings at stations (1 to 12 observations a day). As spatial distribution increases, temporal resolution decreases.

### **Gaps in knowledge?**

At the regional scale, there are two competing factors, scale and process. While a good understanding of process might be available, implementing it with the required data at the correct scale is the challenge. For example, a description of the surface erodible fraction is a basic parameter for input to wind erosion models. The specification of this parameter for a 5km resolution region is not currently possible using remote sensing methods. Therefore, its substitution with particle-size data that does not change with time highlights this dilemma. Future work that estimates those factors that change rapidly in time are a priority for regional scale soil models.

## **Conclusions**

Two methods have been used to assess the extent and magnitude of wind erosion in south-east Australia. There is general agreement between the modelled and the observed patterns. Differences in what each approach measures adds to the difficulty of a direct comparison, ie IWEMS predicts saltation activity and DVI dust transport down with of the source area. Despite this, each approach offers a tool for environmental auditing. Spatially, regions of wind erosion activity can be identified, and temporally, days (down to hours) can be identified when the activity occurred. The IWEMS also helps to explain why the erosion event occurred, eg high wind or low groundcover. The DVR offers a method for validating the outputs of IWEMS.

The challenge for regional wind erosion modelling is match the scale and the temporal frequency of data collection to the models requirements.

## **References**

- McTainsh, G.H., Leys, J.F., and Tews, K. 2001. Wind Erosion Trends from Meteorological Records for the National State of the Environment Key Indicator 1.6. Australian State of the Environment, Second Technical Paper Series (Land). Department of Environment and Heritage, Canberra.
- McTainsh, G.H., and Pitblado, J.R. 1987. Dust storms and related phenomena measured from meteorological records in Australia. *Earth Surface Processes and Landforms*, 12:415-424.
- McTainsh, G.H. and Tews, E.K., 1999. Wind erosion. State of the Environment Report. Department of the Environment, Brisbane.
- Shao, Y., 2000. Physics and Modelling of Wind Erosion. Kluwer Academic, Dordrecht.
- Shao, Y. and Leslie, L.M. 1997. Wind erosion prediction over the Australian continent. *Journal of Geophysical Research*, 102:30,091-30,105.
- Shao, Y. Raupach, M.R. and Leys, J.F. 1996. A model for predicting aeolian sand drift and dust entrainment on scales from paddock to region. *Australian Journal of Soil Research*, 34:309-342.

Tews, E.K., 1996. Wind erosion rates from meteorological records in eastern Australia 1960-92. Unpublished Honours thesis. Griffith University, Brisbane, Australia,